

Simulating Regolith Excavation, Entrainment, Dispersal and Visibility Impairment due to Rocket Plume-Surface Interaction via a Hybrid Continuum-Rarefied Flow Solver

Completed Technology Project (2015 - 2019)



Project Introduction

With NASA planning to redirect an asteroid and possible future missions to the Moon or Martian satellites, the effects of thruster plume impingement on the surfaces of these bodies must be better understood. Thruster firings near a regolith-covered surface will scour and accelerate dust and larger particles, creating a spray of debris that endangers the spacecraft and any nearby equipment. These particle jets may degrade thermal coatings and solar arrays, clog or damage robotic actuators, and severely reduce the effectiveness of optical sensors. Without accurate modeling of this particle behavior, mitigation techniques and safe operational plans cannot be developed. The objectives of my research are: (1) to determine how interactions between variably-oriented unsteady plumes and realistic surfaces can effect the far field distribution of debris, (2) understand and quantify the effect of entrained dust on larger [~ 0.1 -1 cm] pebble- like particles on the surface and the hazard this may pose, and (3) determine how lofted dust degrades the performance of optical instruments and astronaut visibility. Rocket plume interaction with the surface of an asteroid or moon involves a variety of complex phenomena including continuum to rarefied transition, multiphase flow, light scattering, and gas-surface interaction. NASA's proven Data Parallel Line Relaxation (DPLR) CFD code will be used handle the supersonic continuum flow exiting the rocket nozzle. This flow will then be handed off to an in-house direct simulation Monte Carlo (DSMC) code that models the continued expansion of the plume into the rarefied regime. Dust particles will be treated as a separate species in the flow with accurate mass and conservation of momentum characteristics. Using a single photon light scattering code, the optical properties of the dust cloud will be determined. The software resulting from this research will add a considerable new analysis capability for missions at objects in deep space, substantially improving safety and performance. It will allow the development of follow-on mitigation devices and guide the development of in-space operational strategies.

Anticipated Benefits

The software resulting from this research will add a considerable new analysis capability for missions at objects in deep space, substantially improving safety and performance. It will allow the development of follow-on mitigation devices and guide the development of in-space operational strategies.



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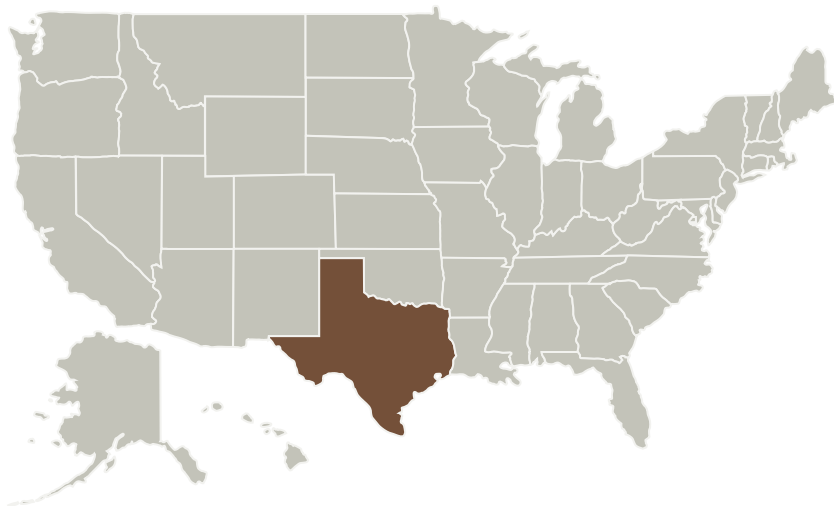
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Primary U.S. Work Locations and Key Partners



Organizations Performing Work	Role	Type	Location
The University of Texas at Austin	Supporting Organization	Academia	Austin, Texas

Primary U.S. Work Locations
Texas

Project Website:

<https://www.nasa.gov/directorates/spacetech/home/index.html>

Organizational Responsibility

Responsible Mission Directorate:

Space Technology Mission Directorate (STMD)

Responsible Program:

Space Technology Research Grants

Project Management

Program Director:

Claudia M Meyer

Program Manager:

Hung D Nguyen

Principal Investigator:

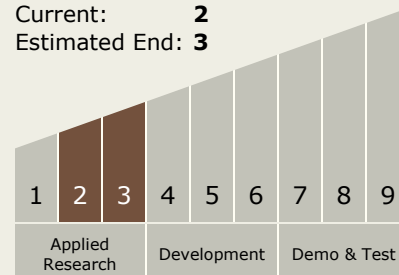
David I Goldstein

Co-Investigator:

Jared J Berg

Technology Maturity (TRL)

Start: 2
Current: 2
Estimated End: 3



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Technology Areas

Primary:

- TX09 Entry, Descent, and Landing
 - └ TX09.4 Vehicle Systems
 - └ TX09.4.5 Modeling and Simulation for EDL